FUEL DELIVERY SYSTEM

Field of the Invention

This invention relates to a fuel delivery system and, in particular, to a fuel delivery system for delivering liquid gas such as liquid petroleum gas, together with diesel fuel to a diesel engine.

Background Art

Our co-pending International Application No. PCT/AU02/00453 discloses a fuel delivery system of the above-mentioned type, which successfully enables a diesel engine to run on both diesel fuel and liquid petroleum gas. The contents of this International application is incorporated into this specification by this reference.

Summary of the Invention

The object of the present invention is to provide further improvements to the fuel delivery system to further increase fuel economy and also to decrease emissions.

The invention may be said to reside in a fuel delivery system for an engine including:

a liquid injector for receiving liquid gas and for ejecting liquid gas in liquid form to the cylinders of an engine;

means for preventing vaporisation or bubbling of the liquid gas in the liquid injector so the liquid gas is ejected from the injector in liquid form;

collection means for collecting vaporised liquid gas; and

a bleed injector for delivering the collected liquid gas vapour to the cylinder of the engine.

The use of both the liquid injector and the bleed injector to deliver liquid gas in liquid form and liquid gas in vapour form to the engine allows both injectors to be

operated so that the liquid gas is delivered only when the inlet valve of the cylinder is open and the exhaust valve of that cylinder is closed, thereby reducing blow-through of fuel and decreasing emissions. Since the supply of vapour is controlled in this manner, the blow-through of the vapour is prevented so that the vapour is actually used as fuel in the engine, thereby increasing power and decreasing unwanted emissions which would otherwise be created if the vapour simply blows through the engine or is not correctly combusted in the engine due to the timing of the delivery of the vapour into the cylinder.

Preferably the system includes a controller for supplying injection pulses to the liquid injector and injection pulses to the bleed injector so that liquid gas in liquid form and liquid gas in vapour form is supplied only when the inlet valve of the cylinder is open and the exhaust valve of the cylinder is closed.

Preferably the system includes liquid gas supply means for supplying liquid gas for ejection by the injector, the collection means comprises a debubbling chamber in which bubbled or vaporised liquid gas is collected, the injector being located in the chamber so that the collected vapour facilitates cooling of the injector, and a vapour supply line for supplying vapour from the chamber to the bleed injector.

Preferably the bleed injector is sized and the injection pulses applied to the bleed injector are of such a length to control the amount of liquid gas in vapour form which is delivered from the bleed injector to the cylinder of the engine.

Preferably a bleed gas heater is provided for heating the vapour before the vapour is supplied to the bleed injector to ensure that the liquid gas supplied to the bleed

Claims

1. A fuel delivery system for an engine including:

a liquid injector for receiving liquid gas and for ejecting liquid gas in liquid form to the cylinders of an engine;

means for preventing vaporisation or bubbling of the liquid gas in the liquid injector so the liquid gas is ejected from the injector in liquid form;

collection means for collecting vaporised liquid gas; and

a bleed injector for delivering the collected liquid gas vapour to the cylinder of the engine.

2. The system according to claim 1 wherein the system includes a controller for supplying injection pulses to the liquid injector and injection pulses to the bleed injector so that liquid gas in liquid form and liquid gas in vapour form is supplied only when the inlet valve of the cylinder is open and the exhaust valve of the cylinder is closed.

3. The system according to claim 1 wherein the system includes liquid gas supply means for supplying liquid gas for ejection by the injector, the collection means comprises a debubbling chamber in which bubbled or vaporised liquid gas is collected, the injector being located in the chamber so that the collected vapour facilitates cooling of the injector, and a vapour supply line for supplying vapour from the chamber to the bleed injector.

4. The system according to claim 1 wherein the bleed injector is sized and the injection pulses applied to the bleed injector are of such a length to control the amount of liquid gas in vapour form which is delivered from the bleed injector to the cylinder of the engine.

5. The system according to claim 1 wherein a bleed gas heater is provided for heating the vapour before the vapour is supplied to the bleed injector to ensure that the liquid gas supplied to the bleed injector is supplied in vapour form for ejection by the bleed injector.

6. The system according to claim 5 wherein the bleed gas heater comprises a heater housing for receiving heated fluid, and a bleed line passing through the heater housing for delivering the vapour to the bleed injector.

7. The system according to claim 6 wherein the heated fluid comprises engine cooling water.

8. The system according to claim 2 wherein the controller comprises the engine control unit of the engine which produces injection pulses for delivery to both the liquid injector and the bleed injector in accordance with engine operating conditions.

9. The system according to claim 8 wherein the pulse supplied to the bleed injector is the same width as the pulse supplied to the liquid injector.

10. The system according to claim 1 wherein the collecting means comprises cooling means for cooling the liquid injector to prevent bubbling or vaporisation of the liquid gas when in the injector.

11. The system according to claim 10 wherein the cooling means includes a housing in which the injector is supported, an inlet in the housing for receiving bubbled liquid gas, and for enabling the bubbled liquid gas to surround the injector in the housing to cool the injector to thereby maintain the liquid gas in the injector in a liquid state, outlet means from the housing for supplying

vapour from the housing to the bleed injector.

12. The system according to claim 11 wherein the bleed gas heater is arranged between the outlet means from the housing and the bleed injector.

13. The system according to claim 11 wherein the housing includes a pressure regulator for regulating the pressure of the vapour in the housing.

14. The system according to claim 13 wherein the pressure regulator comprises a diaphragm, a valve element supported by the diaphragm for closing the inlet, and biasing means for biasing the diaphragm and the valve element towards a closed position, so that when pressure builds up within the housing, the diaphragm is forced against the bias of the biasing means to move the valve element into a closed position, and when pressure reduces in the housing, the biasing means biases the diaphragm to move the valve element to open the inlet.

15. A fuel delivery system for delivering liquid gas to a cylinder of an engine, comprising:

a housing;

a chamber in the housing for receiving an injector which includes a lower opening for enabling liquid gas to be supplied to the injector for ejection from the injector;

a liquid gas inlet communicating with a lower portion of the chamber for introducing liquid gas into the chamber adjacent the lower portion of the injector when the injector is installed in the chamber;

an outlet from the chamber arranged in an upper portion of the chamber; and

a pressure regulator for regulating the pressure of the vapour within the chamber.

16. The system according to claim 15 wherein the housing is in the form of a block and the chamber comprises a bore in the block.

17. The system according to claim 15 wherein the pressure regulator regulates the pressure within the chamber so as to maintain the pressure within the chamber at about the pressure of supply of the liquid gas from a supply tank, and the pressure downstream of the pressure regulator at a relatively low pressure compared to the pressure in the injector chamber.

18. The system according to claim 17 wherein the pressure regulator has an outlet passage which passes through the block in the form of a labyrinth to further facilitate cooling of the block, and therefore the maintenance of liquid gas in the block in a liquid state.

19. The system according to claim 15 wherein the inlet comprises an inlet passage through the block, the inlet passage having a filter cavity for receiving a filter so the liquid gas passes through the filter before delivery to the chamber.

20. The system according to claim 17 wherein the pressure regulator comprises:

a seat;

a seal for seating on the seat;

a piston for moving the seal to sit on the seat;

a first regulator chamber having a first diaphragm having a first area;

a second regulator chamber having a second diaphragm having a second area greater than the first area;

a communication passage for communicating the first chamber with the second chamber; and

wherein when the pressure in the injector chamber

increases to a predetermined amount, the seal is forced away from the seat so vapour and bubble mixture can enter the first chamber and pass into the second chamber through the passage, and because of the differential area between the first diaphragm and the second diaphragm, when the pressure in the first and second chambers reaches a predetermined level, the force on the second diaphragm is greater than the force on the first diaphragm, thereby causing the first and second diaphragms to move to force the piston and therefore the seal against the seat to thereby regulate the pressure in the injector chamber.

21. The system according to claim 20 wherein the first diaphragm is sandwiched between the piston and a retainer, the retainer and piston having a hole for receiving a screw, the second diaphragm being provided on a side of the retainer opposite the first diaphragm, and the communication passage comprising a bore through the piston and a bore through the screw.

22. The system according to claim 20 wherein the pressure regulator comprises:

a seat;

a plunger having a head, the head being locatable against the seat, the plunger further having a stem;

a regulator chamber, a diaphragm forming a wall of the chamber;

biasing means for biasing the diaphragm so as to push the plunger so the head is away from the seat; and

wherein when pressure builds up in the injector chamber, the pressure within the injector chamber and regulator chamber forces the diaphragm away from the plunger against the bias of the biasing means so the plunger can be moved so the head seats on the seat.

23. The system according to claim 15 wherein the outlet communicates with the regulator chamber for

bleeding vapour and bubble mixture in the chamber out of the regulator chamber, so that when the pressure in the regulator chamber decreases, the biasing means biases the plunger away from the seat so the vapour and bubble mixture in the injector chamber can again enter the regulator chamber to force the diaphragm away from the plunger so the plunger can close to shut off the chamber to thereby regulate the pressure within the injector chamber.

24. The system according to claim 23 wherein the diaphragm includes a boss for engaging the plunger.

25. The system according to claim 22 wherein the biasing means comprises a spring and the spring is connected to a screw threaded stem so that the bias supplied by the spring can be adjusted by screw thread adjustment of the screw threaded stem.

26. The system according to claim 22 wherein the pressure regulator regulates the pressure of the vapor within the chamber and also downstream of the regulator so that the pressure within the chamber is maintained at a relatively high pressure, and the pressure downstream of the regulator is at a relatively low pressure so that vapor and bubble mixture which enters the low pressure environment on the downstream side of the regulator can vaporise for delivery to the engine by a vapor bleed injector.